PART III - ICE-PREVENTION SYSTEM

Introduction

Stress studies made on Ross Dam, for the stage with the crest at elevation 1582, took into account maximum flood and earthquake stresses but did not include iceload stresses. This followed the request of the Federal Power Commission that ice be prevented from forming in the vicinity of the spillway gates. In planning an ice-prevention system, it was believed advisable to not only prevent ice from forming in the vicinity of the spillways but also around the entire length of the arch.

Previous extensive investigations of an ice-prevention system for Grand Coulee Dam showed that the air-lift system was the most satisfactory. This system makes use of a series of nozzles on the upstream side of the dam, discharging air into the reservoir 10 feet or more below the surface. The resulting circulation bringing warmer water from below to the surface, prevents the formation of ice near the upstream face of the dam.

The design of the Grand Coulee system was based on tests made on a 1:1 scale model by the Bureau's Hydraulic Laboratory. From these tests, the type of nozzle, the direction of the air jet, the quantity of air necessary at each nozzle, the inside diameter and shape of the nozzle itself, the vertical spacing of the nozzles, and other details were determined. Using this and other data, the details of the Grand Coulee installation were prepared.

When an ice-prevention system for Ross Dam was suggested, the Hydraulic Laboratory was requested to make a preliminary investigation to determine the essentials of the system. During the winter season when freezing would occur, the reservoir will be between elevations 1500 and 1550. The ice-prevention system outlined in this report is similar to the Grand Coulee system and is designed to protect the entire arch from ice pressure with the reservoir above elevation 1500.

Preliminary Considerations

Much of the Grand Coulee Dam ice-prevention system may be adapted for use at Ross Dam. However, certain dissimilarities in the structures
make it necessary to provide a different piping layout for the air supply. The lack of an inspection or operating gallery at a convenient elevation in Ross Dam introduces problems not present at Grand Coulee. Because of the thin arch section, it will not be feasible to construct a gallery in Ross Dam for the installation of compressors, pipes, and headers. Thus, it will be necessary to install the compressors at the roadway elevation, say, in one of the abutments, and run piping through the arch to the nozzles on the upstream face of the dam.

The thin arch section also introduces another problem in that during severe winter conditions, the temperature gradient from the front to the back of the dam may place the air supply pipes in a freezing zone. The piping should be located near the upstream face of the arch and arranged so that freezing of condensed moisture in the pipes be eliminated.

Proposed System

Design

Two horizontal rows of nozzles are considered necessary, the lower at elevation 1490 and the upper at elevation 1530. This should provide complete protection against formation of ice for reservoir elevations 1500 to 1550 and also for rare cases where the reservoir might be above elevation 1550 during the winter season. Two rows are necessary to prevent excessive pressures at the compressor.

From actual experience on Keokuk and other dams, it has been found desirable to place the nozzles between 10 and 12 feet apart, laterally, in each row. Thus, at Ross Dam, where winter conditions can be severe, the 10-foot spacing was necessary.

Assuming 1,000 feet of arch to be protected, there would be 100 nozzles in each row, or a total of 200 nozzles on the upstream face of the dam. If each nozzle discharges 2 cubic feet of free air per minute, this would make a total and maximum discharge of 200 cubic feet of free air per minute, since only one row of nozzles would be discharging at any one time. Air would be supplied by two compressors,
each capable of handling 110 cubic feet of free air per minute. A third compressor, similar to the others, would be necessary as a standby unit and would be interconnected to the other two. It is suggested that these compressors be of the motor-driven air-cooled rotary type similar to those made by the Yeoman Manufacturing Company. Preliminary estimates indicate that the compressors be capable of maintaining a 40 pound per square inch gage pressure during operation of the system.

Figure 30 shows a schematic layout of a suggested installation for Ross Dam. Each of the two operating compressors discharges into a 4-inch header to which are connected four 1-1/4-inch copper distributing pipes, each serving approximately one-eighth of the arch. Each distribution pipe should serve about 12, and not more than 15, nozzles. The nozzles should be connected to the distributing pipes with 1/2-inch copper pipe.

Just below the header, each distributing line should be equipped with a regulating valve and a Bourdon-type gage. Cleanouts should be provided at each end of the distributing lines, in the header, and at each nozzle.

Effectiveness

Since no reliable data are at present available on air and water temperatures, it is not possible to predict accurately the effectiveness of the suggested system. However, based on weather conditions at Ross Dam as reported by a former resident of the area and from experiences at other dams, the suggested system should prevent the formation of ice for a distance of 10 feet upstream from the dam with intermittent operation of 4 hours on and 4 hours off, and be capable of removing 18 inches of ice with 8 hours of continuous operation.

Precautions

There are some precautions to be observed in completing the design of this system. Care should be taken to insure that no nozzle discharges appreciably more than 2 cubic feet of free air per minute. This is necessary to prevent freezing inside the nozzle and also to prevent
unequal distribution to other nozzles on the same supply line. The Bourdon gage readings for various reservoir elevations should be calculated for each row of nozzles to insure the proper distribution and quantity of air. In brief, the system suggested here should be considered a preliminary proposal rather than a final design.

Figure 31 shows the general plan of the Grand Coulee installation, Figure 32 gives the operating diagram and instructions, Figure 33 indicates the type of air supply piping and the details of the nozzles, and Figure 34 lists the parts and sizes. These drawings should prove useful in completing the design of the Ross Dam ice-prevention system.

REFERENCES AND BIBLIOGRAPHY

The enclosed drawings, Figures 30 through 34, showing the installation at Grand Coulee Dam may be used as a guide in completing the design of the Ross Dam system.

The hydraulic laboratory tests on the system installed at Grand Coulee Dam are discussed in Hydraulic Laboratory Report No. 68. This report appears in another form as a paper by T. C. Owen in the Transactions of the A.S.M.E., April 1942, Volume 64, No. 3. Included with this paper is a discussion of the Grand Coulee system by P. J. Bier, who directed the mechanical design work.

Another reference to the Grand Coulee system is contained in the Design Manual, tentative edition, "Penstock and Pipe Design Section of the Mechanical Division of the Branch of Design and Construction, Bureau of Reclamation."
Compressors valved to operate either the elevation 1530
row or the elevation 1490 row.

1/4" Copper distribution lines have 12 and more than 10
nipples per line.

Compressor - motor driven rotary-type, 110 Cu. ft., at
free air per minute at 40 psig gage press.

Provide cleanouts at ends of each nipple and at end of
each distribution line.
### LIST OF PARTS

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### GENERAL NOTE

All parts. joint type of fittings shall be made of cast bronze alloy containing 65% copper, 5% tin, 5% zinc, and 5% lead. All parts indicated as studs, bolts, nuts, and pipe connections are to be properly sized and finished for caps and end type of socket parts. All parts indicated as iron pipe shall have full clean-cut American Standard pipe threads. Complete fitting shall have full clean-cut American Standard pipe threads on all parts, and all parts shall include all types of fittings to be used where water at 90° gage pressure.

All cast pipe size fittings shall be ISI American Standard cast iron pipe fittings. Fittings made from cast bronze containing 65% copper, 5% tin, and 5% zinc shall be cast to American Standard pipe threads. All parts shall be properly sized and finished to match the gage pressure.

All parts of the ground joint type threaded or pipe threads, fitted on a pipe, shall be made in accordance with P-330 and be furnished with a ball and socket joint type, and with 30% finishing. The joint type shall be made of cast bronze alloy containing 65% copper, 5% tin, and 5% lead.

All copper pipe shall be Type 4, non-corrugated, and conform to American Standard Type 4, non-corrugated, and shall not be subject to the requirements for grade K or similar water pipe as prescribed by Federal Specification, P-330, and be furnished semi-finished to be furnished in random lengths, threaded, and coupled.

All parts of the ground joint type shall be made of cast bronze alloy containing 65% copper, 5% tin, and 5% lead.

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